Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (currently amended) A method for modeling injection of a fluid into a mold defining a three dimensional cavity, the method comprising the steps of:

(a) providing a three dimensional ~~solid~~ computer model defining the cavity;

(b) discretizing a solution domain based on the ~~solid~~ model;

(c) specifying boundary conditions;

(d) solving for filling phase process variables ~~using conservation of mass, conservation of momentum, and conservation of energy equations for~~ over at least ~~a portion~~ part of the solution domain ~~based on the boundary conditions~~ to provide respective filling phase solutions therefor ~~for at least the portion of the solution domain~~; and

(e) solving for packing phase process variables ~~using conservation of mass, conservation of momentum, and conservation of energy equations for~~ over at least ~~a portion~~ part of the solution domain ~~based on~~ using respective states of the process variables at termination of filling~~,~~ to provide respective packing phase solutions therefor, ~~for at least the portion of the solution domain; and~~

wherein at least one of steps (d) and (e) comprises the substeps of:

using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain; and

using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second

description comprising conservation of mass, conservation of momentum, and conservation of energy equations.

~~(f) determining whether at least one of the respective filling phase solutions and packing phase solutions are acceptable.~~

Claim 2 (currently amended) The method according to claim 1, wherein the filling phase process variables and packing phase process variables are selected from the group consisting of density, fluidity, mold cavity fill time, mold cavity packing time, pressure, ~~shear~~deformation rate, shear stress, temperature, internal energy, velocity, velocity gradient, flow rate, viscosity, and volumetric shrinkage.

Claim 3 (currently amended) The method according to claim 1, further comprising the steps of:

(f) determining whether at least one of the respective filling phase solutions and packing phase solutions are acceptable;

(g) modifying at least one of the discretized solution domain and the boundary conditions in the event at least one of the respective filling phase solutions and packing phase solutions is determined to be unacceptable; and

(h) repeating steps (d) through (g)~~, iteratively,~~ until the respective filling phase solutions or packing phase solutions are determined to be acceptable.

Claim 4 (currently amended) The method according to claim 1, further comprising the step of: displaying in graphics format a filling phase solution selected from the group consisting of fill time, pressure, ~~shear~~ deformation rate, shear stress, temperature, velocity, and viscosity.

Claim 5 (currently amended) The method according to claim 1, further comprising the step of:

displaying in graphics format a packing phase solution selected from the group consisting of density, packing time, pressure, ~~shear~~ deformation rate, temperature, velocity, viscosity, and volumetric shrinkage.

Claim 6 (currently amended) A method for modeling injection of a fluid into a mold defining a three dimensional cavity, the method comprising the steps of:

(a) providing a three dimensional ~~solid~~ computer model defining the cavity;

(b) discretizing a solution domain based on the ~~solid~~ model;

(c) specifying boundary conditions; and

(d) solving for filling phase process variables ~~using conservation of mass, conservation of momentum, and conservation of energy equations~~ over ~~for~~ at least ~~a portion~~ part of the solution domain, ~~based on the boundary conditions~~ to provide respective filling phase solutions therefor ~~for at least some of the portion of the solution domain; and~~

wherein step (d) comprises the substeps of:

using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain; and

using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second description comprising conservation of mass, conservation of momentum, and conservation of energy equations.

~~(e) determining whether the respective solutions are acceptable for injection of the fluid during filling of the mold cavity.~~

Claim 7 (currently amended) The method according to claim 6, wherein the discretizing step (b) comprises the substep of generating a finite element mesh based on the ~~solid~~ model by subdividing the model into a plurality of connected elements defined by a plurality of nodes.

Claim 8 (original) The method according to claim 6, wherein the boundary conditions are selected from the group consisting of fluid composition, fluid injection location, fluid injection temperature, fluid injection pressure, fluid injection volumetric flow rate, mold temperature, cavity dimensions, cavity configuration, and mold parting plane, and variations thereof.

Claim 9 (currently amended) The method according to claim 6, wherein the solving step (d) utilizing the conservation of mass and conservation of momentum equations comprises the substeps of:

(i) solving for fluidity over ~~for~~ at least ~~some of the portion~~ part of the solution domain;

(ii) solving for pressure over ~~for~~ at least ~~some of the portion~~ part of the solution domain; and

(iii) calculating velocity over ~~for~~ at least ~~some of the portion~~ part of the solution domain.

Claim 10 (currently amended) The method according to claim 9, wherein the solving step (d) utilizing the conservation of energy equation comprises the substep of calculating viscosity over ~~for~~ at least ~~some of the portion~~ part of the solution domain.

Claim 11 (original) The method according to claim 10, wherein the viscosity calculating substep is based on temperature.

Claim 12 (original) The method according to claim 11, wherein at least one of velocity and viscosity is calculated iteratively, until pressure converges.

Claim 13 (currently amended) The method according to claim 12, ~~further comprising~~ wherein the solving step (d) comprises the substep of determining free surface evolution of the fluid in the cavity based on velocity.

Claim 14 (currently amended) The method according to claim 13, ~~further comprising~~ wherein the solving step (d) comprises the substep of calculating temperature based on at least one of a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution.

Claim 15 (original) The method according to claim 14, wherein free surface evolution is determined iteratively, until the cavity is filled.

Claim 16 (currently amended) The method according to claim 6 further comprising the step~~s~~ of:

(~~f~~e) solving for packing phase process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain based in part on respective states of the process variables at termination of filling, to provide respective packing phase solutions therefor for at least some of the portion of the solution domain~~; and~~

~~(g) determining whether the respective packing phase solutions are acceptable for injection of the fluid during packing of the mold cavity~~.

Claim 17 (currently amended) The method according to claim 16, wherein the solving step (~~f~~e) utilizing the conservation of mass and conservation of momentum equations comprises the substeps of:

(i) solving for fluidity over ~~for~~ at least ~~some of the portion~~ part of the solution domain;

(ii) solving for pressure over ~~for~~ at least ~~some of the portion~~ part of the solution domain; and

(iii) calculating velocity over ~~for~~ at least ~~some of the portion~~ part of the solution domain.

Claim 18 (currently amended) The method according to claim 16, wherein the solving step (~~f~~e) utilizing the conservation of energy equation comprises the substep of calculating viscosity over ~~for~~ at least ~~some of the portion~~ part of the solution domain.

Claim 19 (original) The method according to claim 18, wherein the viscosity calculating substep is based on temperature.

Claim 20 (original) The method according to claim 19, wherein at least one of velocity and viscosity is calculated iteratively, until pressure converges.

Claim 21 (currently amended) The method according to claim 20, ~~further comprising~~ wherein the solving step (e) comprises the substep of calculating temperature based on at least one of a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution.

Claim 22 (currently amended) The method according to claim 21, further comprising the step of:

(~~h~~f) calculating mass properties of a component ~~produced in accordance with the boundary conditions~~.

Claim 23 (original) The method according to claim 22, wherein the mass properties are selected from the group consisting of component density, volumetric shrinkage, component mass, and component volume.

Claim 24 (original) The method according to claim 22, wherein at least one of velocity, viscosity, and mass properties is calculated iteratively, until a predetermined pressure profile is completed.

Claim 25 (original) The method according to claim 7, wherein the mesh generating substep comprises generating an anisotropic mesh in thick and thin zones such that mesh refinement provides increased resolution in a thickness direction without increasing substantially mesh refinement in a longitudinal direction.

Claim 26 (new) The method according to claim 1, wherein at a given time step, the first description describes each of the plurality of nodes or elements independently of the others.

Claim 27 (new) The method according to claim 1, wherein the value of the process variable at a first point provided by the first description of the process variable about a first node or element is not necessarily equal to the value of the process variable at the first point provided by the first description of the process variable about a second node or element.

Claim 28 (new) The method according to claim 1, wherein the value of the process variable at a first point provided by the first description of the process variable about a node or element is used in the second description.

Claim 29 (new) The method according to claim 1, wherein the first description is a one dimensional analytic function or is a discrete function.

Claim 30 (new) The method according to claim 1, wherein the first description describes a distribution of temperature or internal energy about a node or element.

Claim 31 (new) The method according to claim 30, wherein the first description is or approximates a solution for one dimensional heat conduction in a solid.

Claim 32 (new) The method according to claim 1, wherein the first description comprises or is derived from an error function.

Claim 33 (new) The method according to claim 1, wherein the first description is a one dimensional description of temperature distribution about a node or element, the description comprising an error function.

Claim 34 (new) The method according to claim 6, further comprising the step of:

(e) determining whether the respective solutions are acceptable for injection of the fluid during filling of the mold cavity.

Claim 35 (new) The method according to claim 6, wherein at a given time step the first description describes each of the plurality of nodes or elements independently of the others.

Claim 36 (new) The method according to claim 6, wherein the value of the process variable at a first point provided by a first description of the process variable about a first node or element differs from the value of the process variable at the first point provided by a first description of the process variable about a second node or element.

Claim 37 (new) The method according to claim 6, wherein the value of the process variable at a first point provided by the first description of the process variable about a node or element is used in the second description.

Claim 38 (new) The method according to claim 6, wherein the first description is a one dimensional analytic function or is a discrete function.

Claim 39 (new) The method according to claim 6, wherein the first description describes a distribution of temperature or internal energy about a node or element.

Claim 40 (new) The method according to claim 39, wherein the first description is or approximates a solution for one dimensional heat conduction in a solid.

Claim 41 (new) The method according to claim 6, wherein the first description comprises or is derived from an error function.

Claim 42 (new) The method according to claim 6, wherein the first description is a one dimensional description of temperature distribution about a node or element comprising an error function.

Claim 43 (new) The method according to claim 6, wherein the solving step (d) utilizing the conservation of mass and conservation of momentum equations comprises the substeps of:

(i) solving for pressure over at least part of the solution domain; and

(ii) calculating velocity over at least part of the solution domain.

Claim 44 (new) The method according to claim 6, wherein the solving step (d) comprises the substep of calculating temperature based on a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution.

Claim 45 (new) The method according to claim 16, wherein the solving step (e) utilizing the conservation of mass and conservation of momentum equations comprises the substeps of:

(i) solving for pressure over at least part of the solution domain; and

(ii) calculating velocity over at least part of the solution domain.

Claim 46 (new) The method according to claim 16, wherein the solving step (e) comprises the substep of calculating temperature based on a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution.

Claim 47 (new) A method for modeling injection of a fluid into a mold defining a three dimensional cavity, the method comprising the steps of:

(a) providing a three dimensional computer model defining a cavity;

(b) discretizing a solution domain based on the model;

(c) specifying boundary conditions; and

(d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain,

wherein step (d) comprises the substep of using an explicit scheme in solving the conservation of energy equation.

Claim 48 (new) The method according to claim 47, wherein the explicit scheme is an explicit temperature convection scheme.

Claim 49 (new) The method according to claim 47, wherein the explicit scheme comprises a one dimensional analytic function, data derived from a one dimensional analytic function, or a discrete function describing the temperature distribution about a node.

Claim 50 (new) The method according to claim 47, wherein the explicit scheme comprises a thermal clock that varies locally and may proceed differently than a global clock.

Claim 51 (new) The method according to claim 50, wherein the thermal clock is a node thermal clock.

Claim 52 (new) The method according to claim 50, wherein step (d) comprises the substep of calculating a Peclet number to estimate relative contributions of convection and conduction to heat transfer at a node.

Claim 53 (new) The method according to claim 47, wherein step (d) comprises determining temperature at an upstream position corresponding to a particle location at a previous time step.

Claim 54 (new) The method according to claim 47, wherein step (d) comprises the substep of calculating contribution to heat transfer due to at least one of viscous dissipation, heat of compression, heat of decompression, heat of solidification, and heat of reaction.

Claim 55 (new) A method for modeling injection of a fluid into a mold defining a three dimensional cavity, the method comprising the steps of:

(a) providing a three dimensional computer model defining the cavity;

(b) discretizing a solution domain based on the model;

(c) specifying boundary conditions; and

(d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain,

wherein step (b) comprises the substeps of:

generating a finite element mesh based on the model by subdividing the model into a plurality of connected elements defined by a plurality of nodes; and

anisotropically refining the mesh such that there are more nodes in a first direction of greater variation of material properties than in a second direction of lesser variation of material properties, the refinement comprising at least one of the substeps of:

calculating a distance from a node to a boundary; and

using a node layer numbering system.

Claim 56 (new) A method for modeling injection of a fluid into a mold defining a three dimensional cavity, the method comprising the steps of:

(a) providing a three dimensional computer model defining the cavity;

(b) discretizing a solution domain based on the model;

(c) specifying boundary conditions; and

(d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain, wherein:

step (b) comprises the substep of generating a finite element mesh based on the model by subdividing the model into a plurality of connected elements defined by a plurality of nodes; and

step (d) comprises the substep of determining a location of a solid/liquid interface, the determination of the interface comprising the substep of determining locations at which a process variable achieves a given value.

Claim 57 (new) The method according to claim 56, wherein the process variable of step (d) which is used to determine a location of a solid/liquid interface is one of the group consisting of temperature, velocity, and a process variable combining temperature and velocity.

Claim 58 (new) The method according to claim 56, wherein step (d) further comprises the substep of determining an effective viscosity for each of a plurality of elements containing the solid/liquid interface by calculating a volume fraction of freeze within the element.

Claim 59 (new) The method according to claim 56, wherein step (d) further comprises the substep of determining an effective pressure at a position in the solution domain by identifying core nodes within the solution domain.

Claim 60 (new) The method according to claim 56, wherein step (d) further comprises the substep of removing from the solution domain nodes corresponding to elements which contain no unfrozen material.

Claim 61 (new) The method according to claim 56, wherein step (d) further comprises the substep of projecting a core pressure onto an outer cavity frozen layer.

Claim 62 (new) A molded plastic component formed from a process developed using the method of at least one of claims 1, 6, 47, 55, and 56.

Claim 63 (new) The method according to claim 56, wherein step (d) further comprises the substep of describing linear variation of a process variable throughout each of a plurality of elements.

Claim 64 (new) The method according to claim 56, wherein step (d) further comprises the substep of using a one dimensional analytic function to describe variation of a process variable about a point.

Claim 65 (new) An apparatus for modeling injection of a fluid into a mold defining a three dimensional cavity, the apparatus comprising:

a memory for storing code that defines a set of instructions; and

a processor for executing said set of instructions to:

(a) discretize a solution domain based on a three dimensional computer model defining a cavity; and

(b) solve for process variables using conservation of mass, conservation of momentum, and conservation of energy equations, wherein an explicit scheme is used to solve the conservation of energy equation.

Claim 66 (new) The apparatus of claim 65, wherein the explicit scheme is an explicit temperature convection scheme.

Claim 67 (new) An apparatus for modeling injection of a fluid into a mold defining a three dimensional cavity, the apparatus comprising:

a memory for storing code that defines a set of instructions; and

a processor for executing said set of instructions to:

(a) discretize a solution domain based on a three dimensional computer model defining a cavity;

(b) at least one of:

(i) solve for filling phase process variables over at least part of the solution domain to provide respective filling phase solutions therefore; and

(ii) solve for packing phase process variables over at least part of the solution domain using respective states of the process variables at termination of filling to provide respective packing phase solutions therefor,

wherein at least one of (i) and (ii) comprises:

using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain; and

using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements,

the second description comprising conservation of mass, conservation of momentum, and conservation of energy equations.